

Beam Pipe ID (in the wall) without NEG Pump  
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The pipe size has to determine in the penetration through the wall from linac side to booster, based on the knowledge we have today (We do not have much information). To determine the pipe size, we should know two parameters: (1) Emittances for all the ion species which we plan to run; (2) The maximum beta functions through the wall.

### 1. Emittance

Sasha's simulations for the EBIS shows that emittance at the entrance of the RFQ is about 0.08 mm mrad(N, RMS) for  $\text{Au}^{+32}$ .

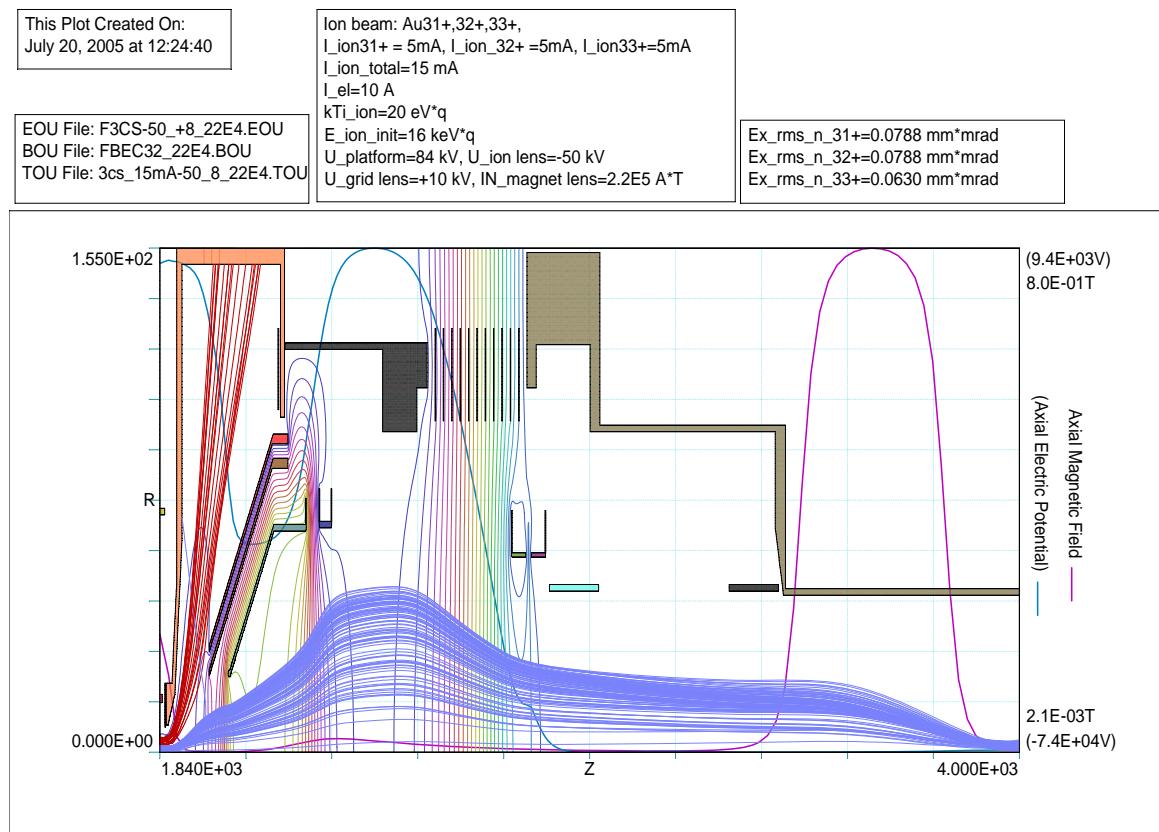


Figure 1: LEBT simulations by Sasha using TRAK code.

This emittance seems to small. Simulations for RFQ assume 0.125 mm mrad (N, RMS) input emittance. Table 1 shows the emittance evolution through the EBIS linac

Table 1: Emittance evolution through the linac for Au<sup>+32</sup>. Quantities shown in parenthesis are un-normalized.

	INPUT (N) mm mr rms	OUTPUT(N) mm mr rms	90%	comments
LEBT	0.035	0.08		input E=2.6keV/u, beta=0.00236,gamaa=1.0000027 Au +32, sasha input conditions, OUTPUT energy=17 keV/u, beta=0.006017,gamma=1.000018 (too low)
RFQ	0.125/125	0.125/.116		input energ 17keV/u, beta=0.006017, 100%unnorm=112.5 (waterbeg), output beta=0.0261,gamma=1.00034,energy=62.09 MeV
MEBT	0.125/.116 (4.8,4.4)	.125/.116 (4.8,4.4)		trace numbers (5 rms unnorm) are 24 and 22 mm mr
IH	0.130/.121	.55/.54	.147/.138	beta=0.0668,gamma=1.0022 (energy 410.627 MeV) generate its own distribution I don't know what type
HEBT	0.147/.138 (2.2,2.056)	0.147/.138 (2.2,2.056)		trace numbers ( 5 rms unnorm) are 11 and 10.28 mm mr

There is not much information available for other ion species. For now we will scale the emittance by Q/M using following formula by Jim.

$$\text{eps}(n) = 0.16 * r^2 * B_z * (Q/M) \text{ m-rad (100% of beam)}$$

For example emittance for the D will be 3 times of Au<sup>+32</sup>. These simulations did not show much emittance growth in RMS quantities.

$$\text{Emittance growth} = \frac{(0.147 + 0.138)/2}{0.125} = 1.14$$

We have budgeted factor of 2 for the emittance growth.

## (2) Beta Function at regions of interest.

Figure 2 shows the trace output for Au<sup>+32</sup> for 4.3 mA in the HEBT. Trace simulations assume 5 time un-normalized emittance given by the LORAS code for IH linac. The maximum beta function in region of interest is about 54 meters. Note that at time of these

simulations, the locations of dipoles, quadrupoles and bunchers are not known with great accuracy(+/- 1 foot).

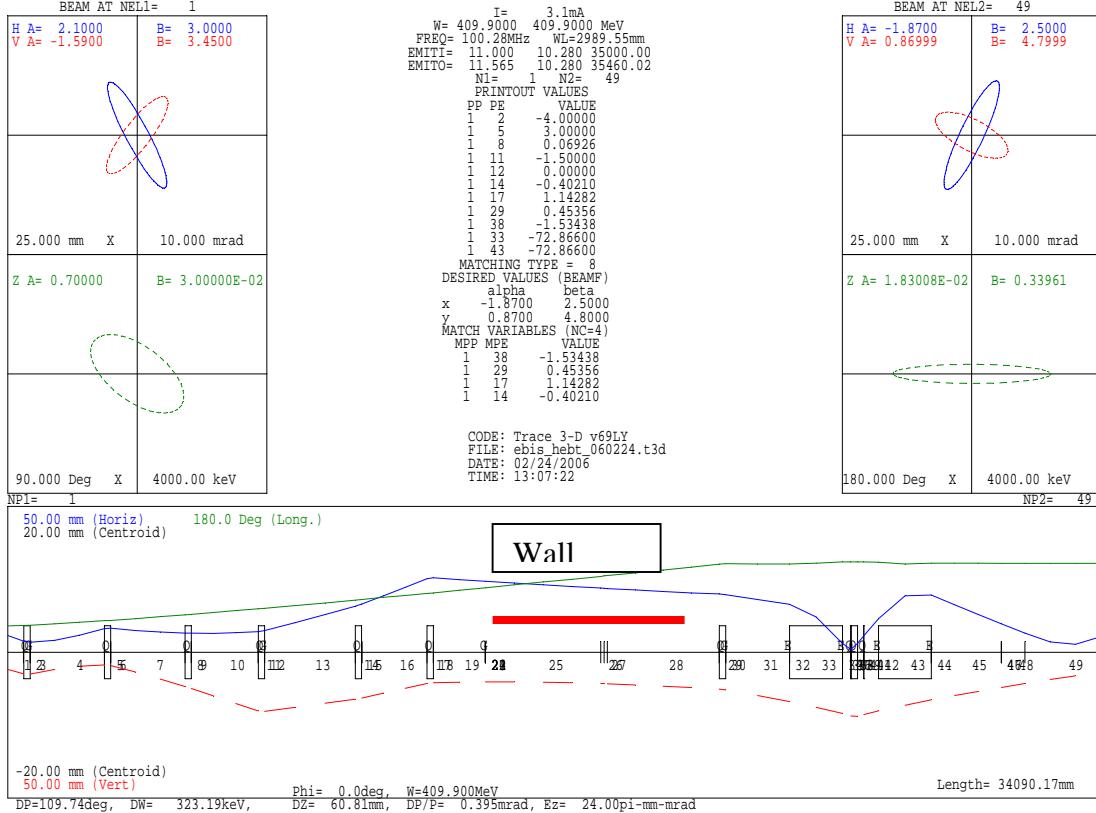


Figure 2: Trace output for  $\text{Au}^{+32}$  for the HEBT.

It is clear from the figure 2 that the maximum beam size in the x-plan in region of interest. We will calculate half beam size in x-plan

maximum beta in the interest region 54 m

5 rms un-normalized emittance 11 mm mrad (simulated emittance) for  $\text{Au}^{+32}$

$$x/2 = \sqrt{11*54} = 24.4 \text{ mm}$$

5 rms budgeted emittance  $11*2 = 22$  (unnorm)

$$x/2 = \sqrt{22*54} = 34.5 \text{ mm}$$

Deutrons

emittance scale as q/m

$11*3 = 33 \text{ mm mr}$  (5 rms un normalized)

$$x/2 = \sqrt{33*54} = 42.2 \text{ mm}$$

if we take same ratio for budgeted emittance

$$x/2 = 41.8 * \sqrt{2} = 59.7 \text{ mm}$$

$$x = 119.4 \text{ mm or } 4.701 \text{ inches}$$

Figure 3 shows the cross section of the beam pipe with NEG pump through the wall.

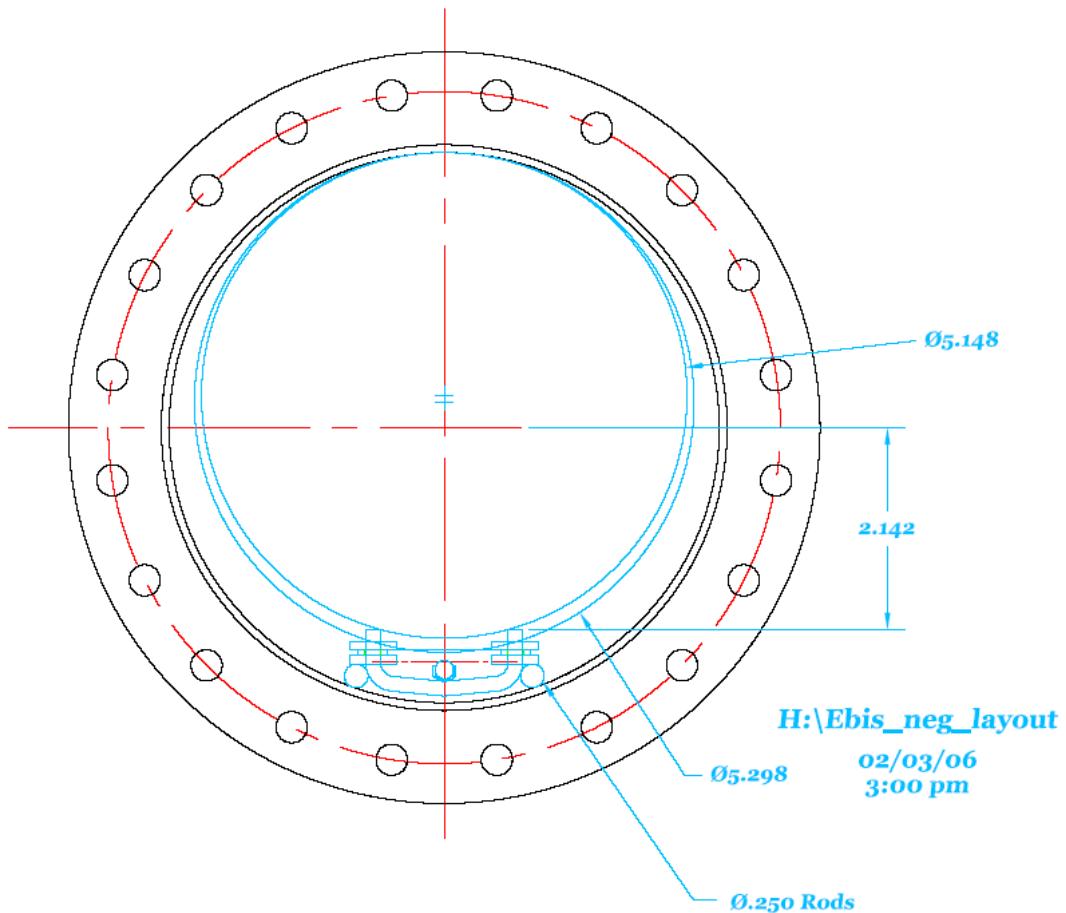


Figure 3: Cross section of the beam pipe through the wall.

Note that acceptance of the inflector is about 29 mmm mrad (un-normalized). If beam emittances are grater than inflector aceeptance, we have to change inflector.

#### Appendix 1

Device	Length (mm)
RFQ	3800
MEBT	1788
LINAC	4000

#### HEBT LOCATIONS

Device	Center of Device	Distance (mm)	arc length (mm)	Dipole angle °	Radius of Dipole (mm)	Overall Distance (mm)
End of IH LINAC		0.00				0.00
		500.00				500.00
Q1	601.6	203.20				703.20
		2311.40				3014.60
Q2	3116.2	203.20				3217.80
		2311.40				5529.20
Q3	5630.8	203.20				5732.40
		2079.50				7811.90
Q4	7913.5	203.20				8015.10
		2827.40				10842.50
Q5	10944.1	203.20				11045.70
		2027.30				13073.00
Q6	13174.6	203.20				13276.20
		8908.72				22184.92
Q7	22286.52	203.20				22388.12
		1990.18				24378.30
D1		959.60	1653.28	72.866	1300	25337.90
		959.60				26297.50
		260.00				26557.50
Q8		203.20				26760.70
		654.00				27414.70
D2		959.60	1653.28	72.866	1300	28374.30
		959.60				29333.90
		4101.75				33435.65
INJ. PT.						33435.65